Thermal Evolution of Compact Stars*

Christoph Schaab[†], *Fridolin Weber*[†], *Manfred K. Weigel*[†] *and Norman K. Glendenning*

A broad collection of modern, field-theoretical equations of state (EOSs) is applied to studying the cooling behavior of both neutron stars and strange matter stars. The collection was derived under numerous assumptions about the behavior of superdense stellar matter. To mention several are: (1) the many-body technique used to determine the equation of state; (2) the model for the nucleon-nucleon interaction; (3) description of electrically charge neutral neutron star matter in terms of either only neutrons, (4) neutrons and protons in generalized chemical equilibrium (β equilibrium) with electrons and muons, or (5) nucleons, hyperons and more massive baryon states in β equilibrium with leptons; (6) behavior of the hyperon coupling strengths in matter, (7) inclusion of meson (π, K) condensation; (8) treatment of the transition of confined hadronic matter into quark matter; and (9) assumptions about the true ground state of strongly interacting matter (i.e., absolute stability of strange quark matter relative to baryon matter).

We find that *standard* cooling gives agreement between the theoretical cooling curves and the observed data for some but not all pulsars (cf. upper band in Fig. 1). On the other hand, the *enhanced* cooling mechanisms, which are connected to higher neutrino-emission rates coming from the direct Urca process, π– and K– meson condensates, or up, down and strange quarks in the cores of neutron stars, lead to too rapid a cooling. Therefore one is left to examine processes which somewhat delay enhanced cooling. A plausible candidate is superfluidity, of which there occur probably two different types in the cores of neutron stars, namely $^1S_0$ and $^3P_2$. We find that already small changes in the theoretical value for the $^1S_0$ gap shift the cooling curves into the region of the observed data, giving an overall good agreement (band labeled "intermediate" in Fig. 1). An accurate determination of the superfluid gaps in neutron star matter therefore attains its particular interest.

With respect to the cooling behavior of strange stars, whose luminosities lie in the lower part of the band labeled "enhanced", we find that pulsars like Geminga, Monogem, and PSR 1055-52 can probably ruled out to be strange pulsar candidates. There is however one pulsar, PSR 1929+10, which could be interpreted as a strange star. Of course, the QCD related uncertainties in the properties of strange matter as well as observational uncertainties do not permit us to draw stringent conclusions yet.

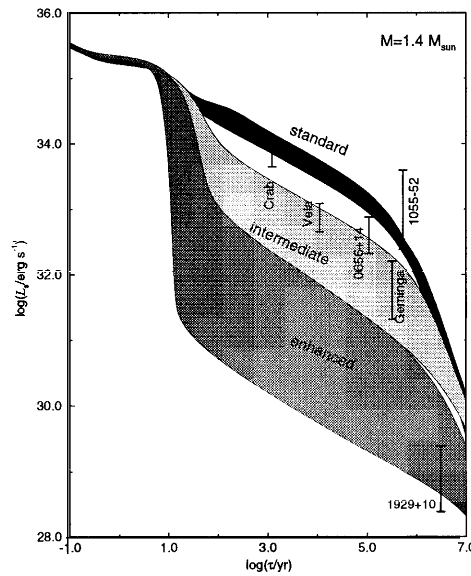

Figure 1: Comparison of the luminosity of observed pulsars with theoretical model calculations. The bands represent uncertainties inherent in the EOS (see text).

* Ch.Schaab, F. Weber, M. K. Weigel and N. K. Glendenning, Nucl. Phys. **A605** (1996) 531.

† Institut fur Theoretische Physik, Ludwig-Maximilians Universität München, Theresienstr. 37, D-80333 München.